

**What is claimed is:**

1           1. A method for receiving a multi-dimensional high-speed signal comprised of a  
2 plurality of bits, via a modem, comprising steps of:

3           receiving a channel output having a plurality of bits where each bit is sent in a  
4 particular dimension;

5           mixing signals of the received channel output with trigonometric signals;

6           retrieving bits in each of the particular dimensions by:

7           demodulating the mixed signals in an orthogonal filter bank of low pass Eigen  
8 filters defined by a transmitted prolate pulse of the channel output;

9           reverse mapping the demodulated mixed signal to recover segmented bits; and  
10          reconstructing an originally transmitted bit pattern to recreate an original signal.

1          2. The method of claim 1, comprising steps of:

2           with a signal comprising  $I_k$  and  $Q_k$  values, demodulating the signal and reverse  
3 mapping the demodulated signal in parallel paths to reconstruct an original transmitted  
4 block of bits at a termination of the parallel paths.

1          3. A high-speed receiver for receiving a multi-dimensional high-speed signal  
2 comprised of a plurality of bits, via a modem, comprising:

3           an input for receiving a channel output signal having a spectral distribution  
4 defined by a prolate pulse;

5           mixing circuitry connected to apply trigonometric mixing signals to the channel  
6 output signal;

7           demodulation circuitry including a plurality of orthogonal filter banks of low pass  
8 eigen filters defined by a transmitted prolate pulse of the channel output; and

9           reverse mapping circuitry connected for reconstructing an originally transmitted  
10 bit pattern to recreate an original signal.

1          4. The high speed receiver of claim 3, further comprising:

2           a plurality of parallel paths, each connected to the input and each path including  
3 a mixer circuit and an Eigen filter; and

4           each path connected to a packet reconstruction circuit.

1           5. A method of high-speed communications for achieving high spectral efficiency  
2 comprising steps of:

3           dividing a transmission channel into a plurality of sub channels;  
4           modulating signals in each sub channel in a numbered plurality of sub  
5 transmitters using discrete prolate functions for capacity optimization;  
6           summing the modulated signals and transmitting the summed signals through a  
7 transmission channel subject to noise;  
8           recovering the individual channels in a plurality of receivers corresponding to the  
9 plurality of sub channels; and reconstructing original bits of the transmission channel by  
10 demodulation techniques.

1           6. The method of claim 5, comprising steps of:

2           reconstructing the original bits includes filtering in low pass Eigen filters.

1           7. The method of claim 6, comprising steps of:

2           reverse mapping to recover segmented bits of an originally transmitted bit  
3 pattern of the high-speed input signal.

1           8. A transmission system for optimizing capacity by achieving high spectral  
2 efficiency, comprising:

3           a plurality of sub transmitters to modulate sub bands of a channel to be  
4 transmitted and achieve high spectral efficiency by basing pulse shapes on a prolate  
5 pulse;

6           a summer for combining modulated signal outputs of the plurality of sub  
7 transmitters;

8           a transmission path connected to transmit an output of the summer and subject  
9 to noise interference;

10          a plurality of sub channel receivers connected to the transmission path, each  
11 having:

12          demodulation circuitry connected to demodulate each sub channel;

13          circuitry to recover bits of each sub channel; and

14          circuitry to reconstruct an original transmitted signal.

9. A method of data transmission and reception over a transmission channel at high spectral efficiency, comprising steps of:

- segmenting the transmission channel into a plurality of sub channels;
- allocating bits of the data transmission to the sub channels based on the existing noise distribution;
- segmenting of bits in each of the sub channels to orthogonal prolate pulses;
- generating symbols from the prolate pulses and modulating the symbols;
- transmitting the symbols in a transmission channel connected to a receiving mechanism;
- demodulating received signals of each sub channel at the receiving mechanism;
- filtering the demodulated symbols to recover transmitted symbols;
- recreating an original data signal by mapping the recovered symbols into bits;

and

- reconstructing the originally transmitted data from the mapped bits.

10. The method of claim 9, including the step of:

- constructing the data transmission to be transmitted over a transmission channel with a form according to

$$x_i(t) = \sum_{k=-\infty}^{\infty} I_k p_i(t - kT).$$

11. The method of claim 10, including the step of:

- constructing the data transmission to be transmitted over a transmission channel within a form according to

$$y_i(t) = \sum_{k=-\infty}^{\infty} Q_k p_i(t - kT).$$

13. The method of claim 9, including the step of:

- allocating bits includes inserting signal data into bins bounded by a bottom limiting noise threshold level and an upper limiting energy limit.

14. The method of claim 13, including the step of:

- controlling signaling power S according to

$$S = \int_{f \in \Omega} B - \frac{N(f)}{|H(f)|^2} df$$

where a region of integration  $\Omega$  is defined by

$$\Omega = \left\{ f : \frac{N(f)}{|H(f)|^2} \leq B \right\}.$$

15. The method of claim 14, wherein the step of:

segmenting bits includes utilizing multiple discrete prolate pulse functions.

16. A transmitter for data transmission over a transmission channel at high spectral efficiency, comprising:

means for segmenting the transmission channel into a plurality of sub channels,

means for allocating bits of the data transmission to the sub channels based on existing noise distribution;

transmitting circuitry in each sub channel including:

means for segmenting the bits in each sub channel to orthogonal prolate pulses;

means for generating symbols from the prolate pulses; and

means for transmitting the symbols in a transmission channel.